W.E.,

621.392.26† : 538.561 2285

Theory of the Excitation of Oscillations in a Waveguide by means of a Linear Aerial. A. I. Akhiezer & G. Ya. Lyubarski. (*Zh. tekh. Fiz.*, Sept. 1950, Vol. 20, No. 9, pp. 1049-1064.) One of the main problems in the theory of aerials is the determination of the current distribution in an aerial to which given electromotive forces are applied. It has been shown by Leontovich & Levin (2618 of 1945) that in the case of an aerial in unlimited space the problem is reduced to the solution of a linear integrodifferential equation. A study is here presented of the current distribution in a linear aerial mounted along the axis of a cylindrical waveguide. In this case it is necessary to solve an equation of the same type as for an aerial in unlimited space. No effective methods of solving this equation for an aerial of arbitrary dimensions are known. The discussion is therefore limited to the case of a sufficiently long and thin aerial and, using a method proposed by Leontovich & Levin (2618 of 1945), an approximate solution of the equation is found by expanding the current in a series of powers of the inverse logarithm of the ratio of the length to the radius of the aerial.

The following two cases are considered separately: (a) when the wavelength differs considerably from the critical wavelength of the waveguide, (b) when this difference is not great. The current distribution in a tuned aerial differs very much from that in an aerial in unlimited space. Simple formulae for determining the amplitudes of the waves excited in the waveguide are also derived.

Aerials and Transmission Lines

Cd 51

ASM-SLA METALLURGICAL LITERATURE CLASSIFICATION

LYUBARSKIY, G. Ya.

USSR/Physics - Nonlinear Plasma Oscillations

11 Sep 51

"Nonlinear Theory of Oscillations of Electron Plasma," A. I. Akhiyezer, G. Ya. Lyubarskiy

"Dok Ak Nauk SSSR" Vol LXXX, No 2, pp 193-195

Solves the simplest uniform nonlinear problem: Considers the longitudinal oscillations in unbounded plasma at abs zero, with the state of the plasma characterized by the ordinarily used distribution function of electron density n(r,t). Acknowledges the interest and valued discussion of Acad L. D. Landau. Submitted by L. D. Landau 18 Jul 51.

221T86

LYUBARSKIY, G. YA.

USSR/Physics - Magnetron, Statistical Theory — 21 May 52

"Statistical Theory of the Magnetron (Statistical State)," G. Ya. Lyubarskiy, L. E. Pargamanik

"Dok Ak Nauk SSSR" Vol LXXXIV, No 3, pp 491-494

Considers a long cylindrical magnetron with complex anode of radius R and with thin axial cathode of smaller radius r; the magnetic field H is parallel to the axis and the applied potential difference is Φ. Explains how far the statistical approach is convenient for description of the statistical state of the magnetron, under the assumption that

225T85

the electrons entering and leaving the electron gas to the electrodes do not markedly disrupt the state of statistical equil. Employs the method of self-matching field in the statistical study. Compares results of the statistical theory with A. Hull's. Submitted by Acad M. A. Leontovich 1 Apr 52.

(PA 56 no. 668: 5543 '53)

225T85

LYUBARSKIY, G. Ya.

USSR/Physics-Endovibrators

FD-1234

Card 1/1 Pub. 153-18/22

Author : Akhieser, A. I. and Lyubarskiy, G. Ya.

Title : Theory of coupled endovibrators

Periodical : Zhur. tekh. fiz., 24, 1697-1706, Sep 1954

Abstract : Proper frequencies of two endovibrators coupled through narrow and long slits in metallic separators are computed. The necessary field equations are derived and integrated. Indebted to Prof. K. D. Sinelnikov, P. M. Zeydlits, O. Zavgorodnyy. Six references including 2 foreign.

Institution :

Submitted : April 3, 1954

USSR/Physics - Endovibrators

FD-3134

Card 1/1 Pub. 153 - 9/19

Author : Akhiyezer, A. I.; Lyubarskiy, G. Ya.

Title : Theory of connected endovibrators. II

Periodical : Zhur. tekh. fiz., 25, No 9 (September), 1955, 1597-1603

Abstract : The authors consider the propagation of waves in a series of indentical endovibrators connected with one another by narrow and long slots for which the parameter a = 1/(ln[L/d]) is considerably less than unity, where L is the length and d is the width of the slot. In the series it is possible then to have the propagation of both endovibratorial and also slot waves whose length is determined by the length of the slot. The pass band in both cases is proportional to the above parameter alpha, excluding the case of resonance between endovibrator and slot waves, when the band remains proportional to the square root of alpha. The displacement of frequency in the absence of resonance both for endovibrator waves and also for slot waves is proportional to parameter alpha and this frequency shift is a linear function of the cosine of psi, the shift in phases between the oscillations in two adjacent endovibrators. In the case of resonance the displacement in frequency is proportional to the square root of the linear function of cosine of psi multiplied by parameter alpha. The authors thank K. D. Sinel'nikov, Ya. B. Faynberg, and P. M. Zeydlits, and O. Zavgorodnyy. One reference: ibid., 24, 1697, 1954.

Submitted : April 1, 1955

LYUBARSKIY, G. Ya.

6 1-2mt

Ahiezer, A. I.; Lyubarskii, G. Ya.; and Fainberg, Ya. B. On the radiation of charged particles moving through coupled resonators. Z. Tehn. Fiz. 25 (1955), 2526–2534. (Russian) 3

The radiation from a charge moving with a constant velocity in a periodic structure is investigated. The method used is based on regarding the motion of the charge as producing forced oscillations in the structure. The radiation is then associated with resonance between the self-oscillations of the structure and the "external force" connected with the moving charge. The condition for resonance determines the radiation spectrum, and the rate of radiation can be calculated. Several examples are treated. One of these deals with a moving oscillating dipole instead of a charge and involves the Doppler effect. It suggests a method for generating micro-waves.

N. Rosen (Haifa).

LYUBARSKIY, G. YA.

Category : USSR/Electronics - Gas Discharge and Gas-Discharge Instruments H-7

Abs Jour : Ref Zhur - Fizika, No 1, 1957, No 1709

Author : Akhiyezer, A.I., Lyubarskiy, G.Ya.
Title : On the Stability of the Distribution Function of Electron Plasma.

Orig Pub : Uch. zap. Khar'kovsk. un-ta, 1955, 64, 13-16

Abstract : An investigation was made of the stability of the stationary state in electron plasma in response to small disturbances. It was established that any monotonically decreasing energy-distribution function is stable with respect to small disturbances of the field and of the density. It is also shown that an electron beam of low density is unstable in the plasma for all electron velocities in the beam and for any dependence of the plasma electron distribution functions on the energy.

Card : 1/1

LYUBARSKIY, G. YA.

AKHIYEZER, A.I.; LYUBARSKIY, G.Ya.; FAYNBERG, Ya.B.

Nonlinear theory of oscillations in plasma. Uch.zap. KHGU 64 no.6:73-80 '55. (MIRA 10:7)
(Electric discharges through gases)

Lyubarskiy

PHASE I BOOK EXPLOITATION 463

Lyubarskiy, Grigoriy Yakovlevich

Teoriya grupp i yeye primeneniye v fizike (Theory of Groups and Its Application in Physics) Moscow, Gostekhizdat, 1957. 354 p. 6,000 copies printed.

Ed.: Goryachaya, M.M.; Tech. Ed.: Gavrilov, S.S.

PURPOSE: This book is intended for senior students of physics in universities, graduate students, and scientific workers specializing in theoretical physics.

COVERAGE: The book is a revision of a course of lectures which the author delivered in the course of a number of years at the University of Khar'kov. The fundamentals of the theory of

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groups are given and certain concrete groups are studied. Compact but detailed and systematic theory of the representation of groups is presented. The representations of such groups which are important in theoretical physics are studied. The principles of the application of abstract concepts of the representation of groups in theoretical physics are demonstrated. Many illustrative examples are given. At the end of the book are tables giving a detailed description of 230 space groups and tables of the characters of certain groups. The author thanks N. Ya. Vilenkin, I. M. Gel'fand, M. G. Kreyin, Ye. M. Lifshits, and O. V. Kovalev for their advice and assistance. There are 85 references, of which 47 are Soviet, 21 English, 13 German, and 4 French.

LYUBARSKIY, G. Ya., AKHYEZER, A. I., FAYNBERG, Ya. B.

"Cerenkov Radiation and the Stability of Beams in the Wave Guides of Slow Waves used in Linear Accelerators," papers presented at CERN Symposium, 1956, appearing in Nuclear Instruments, No. 1, pp. 21-30, 1957

LYBARSKIY, G.

PA - 281e

AUTHOR AKHIYEZER, A., AKHIYEZER, N., LYBARSKIY, G.,

TITLE Effective Boundary Condition on the Sueface of Multiplying and Slowing down Medium.
(Effektivnoye granichnoye usloviye na poverkhnosti razdela mul'tiplitsituyushchey i zamedlyayushchey sred - Russian)

PERIODICAL Zhurnal Tekhn. Fiz., 1957, Vol 27, Nr 4, pp 822-829, (U.S.S.R.)
Received 5/1957 Reviewed 6/1957

ABSTRACT The effectiv boundary condition at the boundary of the multiplicatory- and the slowing down medium are obtained for the case in which the slowing down characteristics of both media are the same. It is assumed that the multiplicatory medium fills the right half-space ($x > 0$) whilst the left half-space is filled by the slower-down (x-great distances from the flat boundary). As the dimensions of the multiplicatory medium are infinite, whilst a steady problem is present, the multiplicatory facter of the neutrons is assumed to be equal to one in the case of the determination of the effective boundary conditions. The equation for the slowing-down process of the fast neutons is set up and is then taken as a diffusion equation and reduced to the form of an integral-differential equation with a difference as kernel. The problem consists in finding an asymptotic representation of $f(\xi)$ with $\xi \gg 1$. $\xi = \frac{x}{L_+}$, where L_+ is the diffusion length of the neutrons with $x > 0$. The problem is solved by applying a method resembling that of Viner-Gopf. In an appendix the exact computation is carried out. (With 3 citations from Slav publications)

Card 1/2

Effective Beundary Conditien en the Surface of Multiplying PA- 281e
and Slewing Dewn Medium.

ASSOCIATION FTI ef the Academy ef Science ef the Ukrainian SSR, Charkew, (FTI AN USSR, Kharkev)
PRESENTED BY
SUBMITTED 1.1e.1956
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Card 2/2

LYUBARSKIY, G. Ya.

56-4-25/52

AUTHOR AKHIYEZER, A.I., KAGANOV, M.I., LYUBARSKIY, G.Ya.

TITLE On the Absorption of Ultrasonics in Metals
(O pogloshchenii ul'trazvuka v metallakh. Russian)

PERIODICAL Zhurnal Eksperim. i Teoret. Fiziki, 1957, Vol 32, Nr 4, pp 837 - 841 (U.S.S.R.)

ABSTRACT When investigating the absorption of sound vibrations in solid bodies, we have to distinguish between two cases. - (a) the frequency of the sound vibrations ω is considerably higher than the reciprocal value of the relaxation time τ, (b) $\omega \ll 1/\tau$. In this first case ($\omega\tau \gg 1$) it is possible to treat the absorption of sound as an absorption of sound quanta with the energy $\hbar\omega$ and with the impulse $\hbar \vec{k}$ ($\vec{k}$ denotes the wave vector of the sound wave). This absorption takes place as result of the collisions of the sound quanta with the quasi-particles characterising the energy spectrum of the solid body, i.e. in the usual dielectric media with the phonons, and in the metals with electrons and phonons. In the second case ($\omega\tau \ll 1$) the sound vibrations may be viewed as a certain external field in which the gas of the quasi-particles is situated and which modulates the energy of these particles.

The paper under review investigates the absorption of sound in the metals at low temperatures. In this case the rôle played by the phonons is unimportant as their number tends towards zero in proportion to T^3 if the temperature is reduced. The absorption of sound is caused by the

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56-4-25/52

On the Absorption of Ultrasonics in Metals

interaction of the sound wave with the conduction electrons. It is possible that also the experimentally observable difference of coefficients of absorption of ultrasound in metals in their normal and in their supraconductive state is connected with this phenomenon. First of all the paper under review discusses the case $\omega\tau \ll 1$. In this context, the changes of the distribution function of the electrons with respect to time and space are essential. The sound field alters the energy of the electrons, and thus also the chemical potential μ and the temperature T are altered. In the metals, heat conductance has at low temperatures no considerable influence on the dissipation of the energy. This dissipation is mainly caused by a "friction" of the electron gas. It is possible to neglect the appearing magnetic field and to consider the electrical field as longitudinal. With the aid of the equation which is obtained by linear approximation it then is possible to determine the dissipation of the energy.

ASSOCIATION Physical-Technical Institute, Academy of Sciences of the Ukrainian SSSR

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SUBMITTED 3 April 1956

AVAILABLE Library of Congress

Card 2/2

Lyubarskiy, G. YA.

PHASE I BOOK EXPLOITATION SOV/4012

Akademiya nauk Ukrainskoy SSR. Otdeleniye fiziko-matematicheskikh nauk. Sessiya po mirnomu ispol'zovaniyu atomnoy energii

Trudy (Transactions of the Session on Peaceful Uses of Atomic Energy), Kiyev, Izd-vo AN Ukrainskoy SSR, 1958. 156 p. 2,500 copies printed.

Resp. Ed.: M. V. Pasechnik, Doctor of Physics and Mathematics; Editorial Board: A. K. Val'ter, Academician, Academy of Sciences Ukrainskaya SSR, O.F. Nemets, Candidate of Physics and Mathematics, M. V. Pasechnik, Doctor of Physics and Mathematics; Ed. of Publishing House: T. K. Remennik; Tech. Ed.: N. P. Rakhlina.

PURPOSE: This collection of articles is intended for physicists and scientific personnel working in nuclear research.

COVERAGE: The articles in this collection discuss linear proton accelerators, electron accelerators, electrostatic accelerators, magnetron lenses, the interaction of charged particles and neutrons with nuclei, the applications of tagged atoms in physics research, and experimental methods. Some of the articles are descriptions of already existing nuclear installations and experimental apparatus. No personalities are mentioned. There is a bibliography of Soviet and non-Soviet sources at the end of most of the articles.

LYUBARSKIY, Grigoriy Yakovlevich; GORYACHAYA, M.M., red.; YERMAKOVA, Ye.A., tekhn.red.

[Theory of groups and its use in physics] Teoriia grupp i ee primenenie v fizike. Moskva, Gos.izd-vo fiziko-matem.lit-ry, 1958. 354 p. (MIRA 12:4)

(Groups, Theory of)

Lyubarskiy, G. Ya.

S/058/60/000/02/13/023

21.1700

Translation from: Referativnyy zhurnal, Fizika, 1960, No. 2, p. 73, # 3070

AUTHORS: Akhiyezer, A. I., Akhiyezer, N. I., Lyubarskiy, G. Ya.

TITLE: The Effective Boundary Condition on the Interface of a Multiplying and Moderating Medium

PERIODICAL: Tr. Sessii AN UkrSSR po mirn. ispol'zovaniyu atomn. energii. Kiyev, AN UkrSSR, 1958, pp. 107-115

TEXT: The distribution of thermal neutrons in a multiplying medium is described by the diffusion equation: $\Delta N_+ + N_+/\lambda^2 = 0$, where $\lambda = L_+/\sqrt{K-1}$, L_+ is the diffusion length, K is the coefficient of multiplication. In a certain region near the boundary of the multiplying medium with a reflector, Equation (1) is not applicable and yields an incorrect expression for N_+. If dimensions of the multiplying medium surpass the thickness of this layer considerably and if the distribution of the neutrons near the boundary is without interest, Equation (1) can be used for solving boundary problems by introducing the effective boundary condition which compensates the incorrectness of the shape of the curve $N_+ (x, y, z)$ near the boundary. In the general case of a boundary of arbitrary shape this condition can be expressed in the form

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S/058/60/000/02/13/023

The Effective Boundary Condition on the Interface of a Multiplying and Moderating Medium

$\partial N_+/\partial \nu = -(b_\infty/a_\infty)\ xN_+/L_+$, where ν is the direction of the inner normal to the boundary surface, a_∞ and b_∞ are coefficients which are chosen in such a way that the asymptotic bahavior of N_+ should coincide with that obtained from the solution of the kinetic equation. An infinitely extended medium is considered which is divided by the plane $x = 0$ into two parts: the left semi-infinite space filled with the moderator, and the right one filled with the multiplying medium. The moderating properties of both media are considered to be equal and $K = 1$. The density n of the superthermal neutrons formed as a result of the moderation of fast neutrons is expressed by the authors in conformity with the age theory. H is assumed that neutrons with an initial energy (age $\tau = 0$) are distributed according to the law $n\ (x,0) = \varepsilon N_+\ (x)$ at $x > 0$, $n\ (x,0) = 0$ at $X < 0$ (ε is a certain coefficient). Then the densities of thermal neutrons in the left and right semi-infinite spaces N_- and N_+ satisfy a system of integro-differential equations of the second order: $d^2N_+/dx^2 = \beta_+ N_+ - (\varepsilon\gamma/2\sqrt{\pi\tau_0})\ I$, $I = \int_0^\infty N_+(x')\ \exp\left[-(x-x')^2/4\tau_0\right] dx'$. Applying a method close to Wiener-Hopf's method the authors succeeded in finding the ratio a_∞/b_∞ in the form of quadratures; for small τ/L_+ ratios a simple analytical expression was found. In the appendix the mathematical apparatus used is applied to a more general integro-differential equation.

Card 2/2

A. Ya. Temkin

AKHIYEZER, A.I. [Akhiiezer, O.I.]; LYUBARSKIY, G.Ya.[Liubars'kyi, H.IA.]; POLOVIN, R.V.

Simple waves in magnetohydrodynamics [with summary in English]. Ukr.fiz.zhur. 3 no.4:433-438 Jl-Ag '58. (MIRA 11:12)

1. Fiziko-tekhnicheskiy institut AN USSR i Khar'kovskiy gosudarstvennyy institut.
(Magnetohydrodynamics)

LYUBARSKIY, G.Ya. [Liubars'kyi, H.IA.]; POLOVIN, R.V.

Simple magnetoacoustic waves. Ukr.fiz.zhur. 3 no.5:567-570 S-O '58. (MIRA 12:2)

1. Fiziko-tekhnicheskiy institut AN USSR i Khar'kovskiy gosudarstvennyy universitet.
(Magnetohydrodynamics)

POLOVIN, R.V.; LYUBARSKIY, G.Ya. [Liubars'kyi, H.IA.]

Impossibility of rarefaction shock waves in magnetohydrodynamics. Ukr.fiz.zhur. 3 no.5:571-574 S-O '58. (MIRA 12:2)

1. Khar'kovskiy gosudarstvennyy universitet i Fiziko-tekhnicheskiy institut AN USSR.

(Magnetohydrodynamics) (Shock waves)

AUTHORS: Kovalev, O. V., Lyubarskiy, G. Ya. 57-28-6-3/34

TITLE: On the Contact of Energy Bands in Crystals (O soprikosnovenii energeticheskikh polos v kristallakh)

PERIODICAL: Zhurnal Tekhnicheskoy Fiziki, 1958, Vol. 28, Nr 6, pp. 1151-1158 (USSR)

ABSTRACT: In the present paper the authors investigated the degeneration of the energy levels of electrons in crystals, which are connected with the spatial symmetry and with the symmetry with respect to a modification of the time signal. It is known that some crystals have no insulated energy bands. The article mentions all spatial groups having these properties. The method employed in this paper for establishing conceptions of spatial groups differs somewhat from those described previously (references 1, 2, and 10). In the electron theory of solids the electron in the crystal is looked upon as a particle in the periodic potential field. Its wave function corresponds to the Schrödinger (Shredinger) equation if it is possible to do without spin-orbital

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interaction. It can be represented as the superposition of the wave functions

$$\psi_{kE}(r, t) = e^{i\left[(kr) - \frac{E}{\hbar} t\right]} U_{kE}(r).$$

If there is no spin-orbital connection, a trivial degeneration always takes place which depends on the orientation of the spin. It is different if spin-orbital connection plays an important part. Trivial degeneration vanishes (reference 4), and taking account of symmetry with respect to the modification of the time signal in every case leads to the conclusion concerning the touching of bands. Therefore, the investigation of every spatial group in the presence of a spin-orbital connection is superfluous. All results obtained which relate to the connection between degeneration of energy levels and the spatial symmetry of the crystal hold not only in the case of electrons but also phonons, spin waves, exitons, and other quasiparticles. Actually, only the fact is utilized that the wave function corresponding to any energy level, because of symmetry transformation, goes over into a function that corresponds to the same energy. It is, however, clear that every function describing the state of the phonons, spin waves, or exitons in the crystal, possesses this property in so far as the transformation of crystal symmetry leaves all conditions of the respective crystal symmetry unchanged. The authors thank I. M. Lifshits for valuable discussions of the subject. There are 1 table and 10 references, 0 of which are Soviet.

ASSOCIATION: Fiziko-tekhnicheskiy institut, AN USSR
(Physical-Technical Institute, AS Ukrainian SSR)
Khar'kovskiy gos. universitet im. A. M. Gor'kogo
(Khar'kov State University imeni A. M. Gor'kiy)

SUBMITTED: November 6, 1956

: 1. Crystals—Energy 2. Nuclear energy levels 3. Electrons—Theory 4. Nuclear spins 5. Mathematics

24 (1), 24 (3)

AUTHORS: Lyubarskiy, G. Ya., Polovin, R. V. SOV/56-35-2-30/60

TITLE: On Simple Magneto-Sound Waves (Prostyye magnitozvukovyye volny)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol 35, Nr 2 (8), pp 509-509 (USSR)

ABSTRACT: The following law was demonstrated in ordinary hydrodynamics: In a simple wave, the points with a high density move faster than the points with a low density if the inequation $(\partial^2(1/\varrho)/\partial p^2) > 0$ is satisfied. In magneto hydrodynamics there are 3 types of simple waves: fast and slow magneto-sonic waves and Alfvén (Al'fven) (magneto-hydrodynamic) waves. The Al'fven waves are characterized by a constant density and by a constant velocity. In the slow and fast magneto-sonic waves the points with higher velocity move faster if the above-given condition is satisfied. This implies in particular the fact that automodel waves are always expansion waves. The dependence of phase velocity on density leads (as also in ordinary hydrodynamics) to the following conclusion: In the

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regions of contraction the liquid continues to contract as long as no shock wave is generated. The authors thank A. I. Akhiyezer and A. S. Kompaneyets for their useful advice. There are 2 references, 2 of which are Soviet.

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Physico-Technical Institute, AS Ukrainskaya SSR)

SUBMITTED: April 4, 1958

10 (4), 24 (3)

AUTHORS: Polovin, R. V., Lyubarskiy, G. Ya. SOV/56-35-2-3'/60

TITLE: The Impossibility of Expansion Shock Waves in Magneto-Hydrodynamics (Nevozmozhnost' udarnykh voln razrezheniya v magnitnoy gidrodinamike)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol 35, Nr 2 (8), pp 510-510 (USSR)

ABSTRACT: The law of Tsemplen remains valid also in magnetic hydrodynamics for any intensity of the explosion and for any direction of the magnetic field if the conditions $(\partial^2(1/\varrho)/\partial p^2)_s > 0$ and $(\partial p/\partial T)_\varrho > 0$ are satisfied. An increase of the pressure in the shock wave causes an increase of density. A formula is given for the calculation of the change of the magnetic field $H_\perp$ when a shock wave passes by. Weak magnetic fields are intensified, but strong magnetic fields become weaker. This is an argument in favor of a certain equalizing influence of the shock waves. The authors thank A. I. Akhiyezer and A. S. Kompaneyets for useful advice. There are 4 references, 4 of which are Soviet.

Card 1/2

The Impossibility of Expansion Shock Waves in Magneto-Hydrodynamics SOV/56-35-2-31/60

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Physico-Technical Institute, AS Ukrainskaya SSR)

SUBMITTED: April 4, 1958

SOV/56-35-3-25/61

24(3), 10(4)

AUTHORS: Akhiyezer, A. I., Lyubarskiy, G. Ya., Polovin, R. V.

TITLE: On the Stability of Shock Waves in Magnetohydrodynamics (Ob ustoychivosti udarnykh voln v magnitnoy gidrodinamike)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol 35, Nr 3, pp 731-737 (USSR)

ABSTRACT: The present paper aims at investigating the stability of plane magnetohydrodynamic shock waves against minor disturbances in dependence on the distance to the explosion front and on time. It is shown that magnetohydrodynamic shock waves become instable and may be split up into several shock waves if the number of magnetohydrodynamic, magnetosound-, and entropy waves leaving the explosion front is different from six. The method of investigation is then described. By basing on the system of equations (1) $\sum_{k=1}^{n}\left\{X_{ik}(u)\frac{\partial u_k}{\partial x} + T_{ik}(u)\frac{\partial u_k}{\partial t}\right\} = 0$; $i = 1,2,\ldots n$, where u_k is the total of hydrodynamic quantities (velocity v, magnetic field H, density ϱ, entropy s); $X_{ik}(u)$ and $T_{ik}(u)$ are

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On the Stability of Shock Waves in Magnetohydrodynamics

functions of $u_1, u_2, \ldots u_n$; x is the distance to the explosion front, and t denotes the time. (1) is, in the following, linearized for u_{1k} and u_{2k}, and the system of equations (2) thus obtain.d is solved. Investigation of stability of shock waves is b d on Syrovatskiy's (Ref 2) assumption that in magnetohydrodynamics there are seven types of onedimensional plane waves: 1) magnetohydrodynamic waves with the phase velocities $v_x - V_x$, $v_x + V_x$, where $V_x = H_x/\sqrt{4\pi\varrho}$; 2) magnetic sound waves with the phase velocities $v_x - u_-$, $v_x + u_-$, $v_x - u_+$ and $v_x + u_+$, where $u_\pm^2 = \frac{1}{2}\left[V^2 + c^2 \pm \sqrt{(V^2 + c^2)^2 - 4c^2V_x^2}\right]$, $\vec{V} = \vec{H}/\sqrt{4\pi\varrho}$ (c = velocity of sound); 3) entropy waves the phase velocity of which coincides with the velocity of the liquid v_x. It holds that (8): $u_- \leq V_x \leq u_+$. In the following it is shown what waves show convergence and divergence respectively at what phase velocities. Stability is obtained only in the following 3 cases:

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SOV/56-35-3-25/61

On the Stability of Shock Waves in Magnetohydrodynamics

$$\begin{array}{lll} \text{A)}\ u_{-1} < v_{1x} < V_{1x}, & v_{2x} < u_{2-} & \\ \text{B)}\ V_{1x} < v_{1x} < u_{1+}, & u_{2-} < v_{2x} < V_{2x} & (9) \\ \text{C)}\ u_{1+} < v_{1x} & V_{2x} < v_{2x} < u_{2+} & \end{array}$$

(cf. Fig 1).
The authors further investigate such cases in which the magnetic field develops parallel to the wave front and in which it is vertical to it; the respective conditions for stability are given (equations 10-13). In conclusion the case of an Al'fven rotary shock wave is investigated and the conditions of stability according to scheme (9) are discussed for various cases. The authors thank L. D. Landau, A. S. Kompaneyets, and G. I. Barenblatt for discussions and advice. There are 6 figures and 2 references, which are Soviet.

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Physico-Technical Institute of the Academy of Sciences, Ukrainskaya SSR)

Card 3/3

SOV/56-35-5-39/56

24(3), 21(7)

AUTHORS: Lyubarskiy, G. Ya., Polovin, R. V.

TITLE: The Splitting-Up of a Small Explosion in Magnetohydrodynamics (Rasshchepleniye malogo razryva v magnitnoy gidrodinamike)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol 35, Nr 5, pp 1291-1293 (USSR)

ABSTRACT: N. E. Kotchine (Kochin) (Refs 1, 2) in 1926 investigated the problem of the decay of any hydrodynamic plane explosion, basing mainly on the fact that on each side of the primary explosion, either a shock wave or an automodel-like rarefaction wave may be propagated. In magnetic hydrodynamics decay is, as a rule, much more complicated: On each side of the primary explosion up to 3 waves (shock waves or automodel-like waves) can be propagated. In magnetohydrodynamics there are three different types of steady shock waves (fast and slow magnetosonic waves and magnetohydrodynamic waves) as well as two types of automodel-like waves (fast and slow magnetosonic waves). Because of the difference in propagation velocity, up to 3 waves of the aforementioned types can propagate in each direction starting from the point of the primary explosion.

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SOV/56-35-5-39/56

The Splitting-Up of a Small Explosion in Magnetohydrodynamics

The initial explosion is characterized by 7 parameters. As each wave is characterized by a parameter, the initial explosion is split up into 7 waves: three of them move towards the left, three to the right, and one remains immobile. It is necessary that in each direction waves of three different types develop: first, a fast magnetosonic wave (shock wave or automodel-like wave), followed by an Alfvén (Al'fven) shock wave, and behind the latter a slow magnetosonic wave (shock wave or automodel-like wave). The problem consists in the suitable selection of the amplitudes of these 7 waves, so that transition from the state on the left of the primary explosion to the state to the right of it can be performed. For reasons of greater simplicity, the authors confine their investigation to a very small primary explosion, in which case all secondary discontinuities are small as well. The relations between the discontinuities of the magnetohydrodynamic quantities in the automodel-like and shock waves are the same as between the amplitudes of the corresponding linearized wave . These relations are given for the following waves: Magnetosonic waves, Alfven shock waves, contact-discontinuity. The sum of the discontinuities of each magnetohydrodynamic quantity on the 7

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waves formed is equal to the primary discontinuity. In this way 7 equations with 7 unknowns are obtained, by solving of which it is possible to calculate all discontinuities. The authors thank Professor A. I. Akhiyezer for valuable advice. There are 5 references, 4 of which are Soviet.

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Physico-Technical Institute of the Academy of Sciences, Ukrainskaya SSR)

SUBMITTED: June 30, 1958

Lyubarskiy, G. Ya

Voprosy Magnitnoy Gidrodinamiki i Dinamiki Plazmy. Trudy Konferentsii Po Magnitnoy Gidrodinamike, Riga, 2-10 Iyulya 1958 g. (Problems of Magnetohydrodynamics and Plasma Dynamics. Works of the Conference On Magnetohydrodynamics, Riga, 2-10 July 1958), Riga, 1959, 339 pp

The majority of the texts of the 55 conference reports and discussions of reports are presented in the source in abridged form. Previously published reports are included there as brief abstracts only. The material published there for the first time (abridged and unabridged) are as follows:

"The Role of Magnetohydrodynamics and Plasma Dynamics in Certain Problems of Astrophysics," by D. A. Frank-Kamenetskiy, Moscow, pp 7-11

"Magnetohydrodynamics and the Study of Variations of Cosmic Rays," by L. I. Dorman, Moscow, pp 13-44

"Cosmic Ray Spectra and Their Role in Cosmic Gas Dynamics," by S. I. Syrovatskiy, Moscow, pp 45-48

"The Influence of a Magnetic Field on the Stability of Flow of a Conducting Fluid," by Ye. P. Velikhov, Moscow, pp 49-58

"Some Problems of the Motion of a Rarefied Plasma in a Magnetic Field," by Ya. P. Terletskiy, Moscow, pp 59-62

"On Nonlinear Steady-State Motions of a Rarefied Plasma in a Magnetic Field," by R. Z. Sagdeyev, Moscow, pp 63-65

"On One Criterion of Applicability of the Equations of Magnetohydrodynamics to a Plasma," by S. I. Braginskiy, Moscow, pp 67-71 (Discussion of the report by R. V. Polovin, Khar'kov, pp 71-72)

"On the Possibility of Accelerating Charged Particles by Means of Shock Waves in a Magnetized Plasma," by L. I. Dorman and G. I. Freydman, Moscow and Gor'kiy, pp 77-81

"On the Acceleration of Charged Particles During Powerful Impulse Discharges and During the Collision of Magnetized Clouds," by L. I. Dorman, Moscow, pp 83-88

"The Influence of a Longitudinal Magnetic Field on the Temperature of the Electrons in a Plasma," by M. V. Konyukov, Tula, pp 89-92

"Investigation of Certain Characteristics of a Plasma of Xenon and Argon Behind a Powerful Shock Wave," by S. R. Kholev, Moscow, pp 93-105

"Observation of Electrodynamic Contraction of an Arc With the Aid of an Electron-Optical Converter," by V. L. Granovskiy, K. P. Prumina, V. I. Savoshkin, and G. G. Timofeyeva, Moscow, pp 107-115

"On the Interaction of Weak Perturbations With Discontinuities and the Stability of Shock Waves in Magnetohydrodynamics," by V. M. Kontorovich, Khar'kov, pp 117-125

"On the Stability of Shock Waves in Magnetohydrodynamics," by S. I. Syrovatskiy, Moscow, pp 127-131

"On the Scattering of Hydromagnetic Waves on Turbulent Fluctuations," by A. G. Sitenko and Yu. A. Kirochkin, Khar'kov, pp 143-146

"On the Damping of Magnetohydrodynamic Waves in a Plasma," by R. Z. Sagdeyev, Moscow, pp 147-149

"Simple Waves in Magnetohydrodynamics," by A. I. Akhyezer, G. Ya. Lyubarskiy, and R. V. Polovin, Khar'kov, pp 151-157

"Two-Dimensional Problems of Magnetohydrodynamics," by G. S. Golitsyn, Moscow, pp 161-165

"On Wave-Induced Flows in Magnetohydrodynamics," by A. I. Ivanovskiy, Moscow, pp 167-171

"Oscillations of an Infinite Gas Cylinder With Its Own Gravitation in a Magnetic Field," by I. M. Yavorskaya, Moscow, pp 175-183

"On Magnetic Boundary Layers and Electric Current Discharges in Moving Media," by V. N. Zhigulev, Moscow, pp 185-190

PHASE I BOOK EXPLOITATION SOV/3762

Konferentsiya po magnitnoy gidrodinamike. Riga, 1958.

Voprosy magnitnoy gidrodinamiki i dinamiki plazmy; trudy Konferentsii. (Problems in Magnetohydrodynamics and Plasma Dynamics; Transactions of a Conference) Riga, Izd-vo AN Latviyskoy SSR, 1959. 343 p. Errata slip inserted. 1,000 copies printed.

Sponsoring Agency: Akademiya nauk Latviyskoy SSR. Institut fiziki.

Editorial Board: D.A. Frank-Kamenetskiy, Doctor of Physics and Mathematics, Professor; A.I. Vol'dek, Doctor of Technical Sciences, Professor; I.M. Kirko, Doctor of Physics and Mathematics; V.Ya. Veldre, Candidate of Physics and Mathematics; V.G. Vitol, Candidate of Physics and Mathematics; Yu.M. Kruzin'; and V.Ya. Kravchenko.

Ed.: A. Teytel'baum; Tech. Ed.: A. Klyavinya

PURPOSE: This book is intended for physicists working in the field of magnetohydrodynamics and plasma dynamics.

COVERAGE: This volume contains the transactions of a conference held in Riga, June 1958, on problems in applied and theoretical magnetohydrodynamics. The objects of the conference were the investigation of the basic trends in theoretical and applied magnetohydrodynamics, establishing contact between the people doing research in different branches of magnetohydrodynamics, and promoting the participation of theoretical physicists in problems in applied magnetohydrodynamics. More than 160 persons from different parts of the Soviet Union took part in the conference, and 55 papers were read. Similar conferences are to be held regularly in the future; the next such conference is scheduled to be held in Riga in June 1960. In this present collection of the transactions of the conference, most of the papers and comments on papers are presented by the authors themselves in an abridged form. The book is divided into two parts: the first part deals with problems in theoretical magnetohydrodynamics and plasma dynamics, and consists of 35 articles on such aspects of the problem as the application of magnetohydrodynamics in astrophysics (D.A. Frank-Kamenetskiy), magnetohydrodynamics and the investigation of cosmic-ray variations (L.I. Dorman), acceleration of plasma in a magnetic field (G.V. Gordeyev and K.I. Gubanov), stability of shock waves and magnetohydrodynamics (A.I. Akhiyezer). The second part, consisting of 33 articles, deals with problems of experimental magnetohydrodynamics, including the application of physical simulation for investigation of electromagnetic processes in liquid metals (I.M. Kirko) and the development of electromagnetic pumps (P.G. Kirillov), at the Institute of Physics of the Academy of Sciences, Latvian SSR. Several articles are devoted to induction pumps, electromagnetic crucibles, electromagnetic stirrers for molten metals, and their application in the metallurgical industry including schematic diagrams of their power-supply systems. References are given at the end of most of the articles.

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LYUBARSKIY, G. Ya.

PHASE I BOOK EXPLOITATION SOV/3762

Konferentsiya po magnitnoy gidrodinamike. Riga, 1958.

Voprosy magnitnoy gidrodinamiki i dinamiki plazmy; trudy Konferentsii. (Problems in Magnetohydrodynamics and Plasma Dynamics; Transactions of a Conference) Riga, Izd-vo AN Latviyskoy SSR, 1959. 343 p. Errata slip inserted. 1,000 copies printed.

Sponsoring Agency: Akademiya nauk Latviyskoy SSR. Institut fiziki.

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LYUBARSKIY, G. YA.

PHASE I BOOK EXPLOITATION SOV/3762

Konferentsiya po magnitnoy gidrodinamike. Riga, 1958.

Voprosy magnitnoy gidrodinamiki i dinamiki plazmy; trudy Konferentsii. (Problems in Magnetohydrodynamics and Plasma Dynamics; Transactions of a Conference) Riga, Izd-vo AN Latviyskoy SSR, 1959. 343 p. Errata slip inserted. 1,000 copies printed.

Sponsoring Agency: Akademiya nauk Latviyskoy SSR. Institut fiziki.

Editorial Board: D.A. Frank-Kamenetskiy, Doctor of Physics and Mathematics, Professor; A.I. Vol'dek, Doctor of Technical Sciences, Professor; I.M. Kirko, Doctor of Physics and Mathematics; V.Ya. Veldre, Candidate of Physics and Mathematics; V.G. Vitol, Candidate of Physics and Mathematics; Yu.M. Kruzin'; and V.Ya. Kravchenko.

Ed.: A. Teytel'baum; Tech. Ed.: A. Klyavinya

PURPOSE: This book is intended for physicists working in the field of magnetohydrodynamics and plasma dynamics.

COVERAGE: This volume contains the transactions of a conference held in Riga, June 1958, on problems in applied and theoretical magnetohydrodynamics. The objects of the conference were the investigation of the basic trends in theoretical and applied magnetohydrodynamics, establishing contact between the people doing research in different branches of magnetohydrodynamics, and promoting the participation of theoretical physicists in problems in applied magnetohydrodynamics. More than 160 persons from different parts of the Soviet Union took part in the conference, and 55 papers were read. Similar conferences are to be held regularly in the future; the next such conference is scheduled to be held in Riga in June 1960. In this present collection of the transactions of the conference, most of the papers and comments on papers are presented by the authors themselves in an abridged form. The book is divided into two parts: the first part deals with problems in theoretical magnetohydrodynamics and plasma dynamics, and consists of 35 articles on such aspects of the problem as the application of magnetohydrodynamics in astrophysics (D.A. Frank-Kamenetskiy), magnetohydrodynamics and the investigation of cosmic-ray variations (L.I. Dorman), acceleration of plasma in a magnetic field (G.V. Gordeyev and A.I. Gubanov), stability of shock waves and magnetohydrodynamics (A.I. Akhiyezer). The second part, consisting of 33 articles, deals with problems of experimental magnetohydrodynamics, including the application of physical simulation for investigation of electromagnetic processes in liquid metals (I.M. Kirko) and the development of electromagnetic pumps (P.G. Kirillov), at the Institute of Physics of the Academy of Sciences, Latvian SSR. Several articles are devoted to induction pumps, electromagnetic crucibles, electromagnetic stirrers for molten metals, and their application in the metallurgical industry including schematic diagrams of their power-supply systems. References are given at the end of most of the articles.

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LYUBARSKIY, G. YA.

21(0) PHASE I BOOK EXPLOITATION SOV/2081

International Conference on the Peaceful Uses of Atomic Energy, 2d., Geneva, 1958

Doklady sovetskikh uchenykh; yadernaya fizika (Reports of Soviet Scientists; Nuclear Physics) Moscow, Atomizdat, 1959. 552 p. (Series: Its: Trudy, Vol. 1) 8,000 copies printed.

Eds. (Title page): A.I. Alikhanov, Academician; V.I. Veksler, Academician; and N.A. Vlasov, Candidate of Physical and Mathematical Sciences; Ed. of this volume: S.I. Bresdev and B.P. Zaretskiy, Candidates of Physical and Mathematical Sciences; Ed. (Inside book): G.L. Smolyan; Tech. Ed.: Ye.I. Mazel'.

PURPOSE: This collection of articles is intended for scientific research workers and other persons interested in nuclear physics. The volume contains 43 papers presented by Soviet scientists at the Second Conference on Peaceful Uses of Atomic Energy, held in Geneva in September 1958.

COVERAGE: It is divided into two parts. Part I contains 17 papers dealing with plasma physics and controlled thermonuclear reactions, and Part II contains 26 papers on nuclear physics, including problems of particle acceleration and of cosmic ray physics. The first paper by L.A. Artsimovich presents a review of Soviet work on controlled thermonuclear reactions. The remaining papers in Part I deal with particular problems in this field. papers in Part II deal in detail with various problems in nuclear physics, such as the fission of heavy atoms and their isotopes, and with the study of cosmic radiation by means of artificial earth satellites and rockets, described in a paper by S.N. Vernov. The Russian-language edition of the proceedings of the conference is published in 16 volumes. The first 6 volumes contain all the papers presented by Soviet scientists as follows: Volume (1), Yadernaya fizika (Nuclear Physics); Volume (2), Yadernyye reaktory i yadernaya energetika (Nuclear Reactor and Nuclear Power); Volume (3), Yadernoye goryucheye i reaktornyye metally (Nuclear Fuel and Reactor Metals), Volume (4), Khimiya radioelementov i radiatsionnykh prevrashcheniy (Chemistry of Radioelements and of Radiation Transformations); Volume 5, Radiobiologiya i radiatsionnaya meditsina (Radiobiology and Radiation Medicine); Volume (6) Polucheniye i primeneniye izotopov (Production and Use of Isotopes). The other 10 volumes contain selected papers presented at the Conference by non-Soviet scientists. In the present volume discrepancies between the English and Russian language) edition of the proceedings have been noted in three articles where the texts are not identical; viz; Andrianov, et al, "High Current Pulsed Discharge"; Akhiyezer, et al, "High Frequency Plasma Oscillation"; and Bogolyubov, "Investigations of the Many-body Problem". The serial numbers of reports 2302 and 2504 are reversed in the English edition. Report 2211, by Simelnikov, et al, is numbered 2536 in the English edition.

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Reports of Soviet Scientists; Nuclear (Cont.) SOV/2081

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30848
S/044/61/000/008/020/039
C111/C333

3,2600(1502)

AUTHORS: Akhiyezer, A. J., Lyubarskiy, G. Ya., Polovin, R. B.

TITLE: Simple waves in magnetic hydrodynamics

PERIODICAL: Referativnyy zhurnal, Matematika, no. 8, 1961, 56, abstract 8B244. ("Vopr. magnitn. gidrodinamiki i dinamiki plazmy" Riga, AN Latv SSR, 1959, 151-157)

TEXT: The authors describe a method for finding out simple plane waves with a finite amplitude of oscillation in magnetic hydrodynamics. The basic system of equations of magnetic hydrodynamics is schematically represented in the unidimensional case in the form

$$\sum_{k=1}^{n} X_{ik}(u) \frac{\partial u_k}{\partial x} + T_{ik}(u) \frac{\partial u_k}{\partial t} = 0; \; i = 1,2,\ldots, n, \qquad (1)$$

where u_k is the totality of the hydrodynamic parameters, X_{ik} and T_{ik} -- certain functions of u_k. The authors interprete all the functions u_k as functions of one of them: $u_k = u_k(u_1(x, t))$, substitute this into

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S/044/61/000/008/020/039
C111/C333

Simple waves in magnetic . . .

(1) and obtain a system of ordinary differential equations for the determination of u_k:

$$\frac{du_k}{du_1} = U_k(u_1, u_2, \ldots, u_n) .$$

4

The form of the functions U_k is determined from the known solutions of the linearized system of equations (1). Simple plane waves with arbitrary amplitude of oscillation are investigated. In the domain adjecent to the constant flow the authors prove the uniqueness of the plane wave solution of (1).

[Abstracter's note: Complete translation.]

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28369
S/124/61/000/008/008/042
A001/A101

10.2000
26.1410

AUTHORS: Akhiyezer, A.I., Lyubarskiy, G.Ya., Polovin, R.V.

TITLE: On the theory of plain and shock magnetohydrodynamical waves

PERIODICAL: Referativnyy zhurnal.Mekhanika, no. 8, 1961, 3-4, abstract 8B17 ("Tr. 2-y Mezhdunar. konferentsii po mirn. ispol'zovaniyu atomn. energii, 1958, T.1. Yadern. fiz.", Moscow, Atomizdat, 1959, 213-220)

TEXT: The authors point at the existence of plane non-stationary plain magnetohydrodynamical waves, each of which propagates in an immovable gas with one of the velocities of small disturbance propagation. It is shown that phase velocity within the wave increases with increasing density, if the following relation is fulfilled:

$$\left(\frac{\partial^2}{\partial p^2}\frac{1}{\rho}\right)_s > 0$$

where p is pressure, ρ is density, S is entropy. The interaction of magnetohydrodynamical shock waves with plane waves of small disturbances is considered. It is concluded that the necessary condition for the stability of a wave is as

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28369

On the theory of plain and shock ... S/124/61/000/008/008/042
A001/A101

follows: velocities of gas behind the wave and before it should be such that the number of small disturbances of various types diverging from the wave to both sides should be equal to six. By analyzing the shock adiabatic curve, it is established in magnetic hydrodynamics that in media in which relations

$$\left(\frac{\partial^2}{\partial p^2}\frac{1}{\rho}\right)_s > 0, \left(\frac{\partial p}{\partial T}\right)_\rho > 0$$

are fulfilled, shock waves accompanied by entropy growth are compression waves. It is concluded from the equation which relates the magnitude behind the shock wave to that before it, that magnetic field in the wave varies depending on the relation between densities and velocities.

A. Kulikovskiy

[Abstracter's note: Complete translation]

Card 2/2

SOV/70-4-1-22/26

AUTHORS: Lyubarskiy, G.Ya. and Kovalev, O.V.

TITLE: Phase Transitions of the Second Order in Crystals with Symmetry T_h^6 (Fazovyye perekhody vtorogo roda v kristallakh s simmetriyey T_h^6)

PERIODICAL: Kristallografiya, 1959, Vol 4, Nr 1, p 121 (USSR)

ABSTRACT: An analysis is given of the space groups to which crystals of the space group T_h^6 can pass by a second-order phase transition. Examples are FeS_2, $CoSe_2$, SnI_4, $ZrCl_4$, $Pb(NO_3)_2$, PbP_2O_7. The theory was given by Landau (Ref 1). According to this theory, there is, connected with each phase transition of the second order, a certain unreduced representation of the symmetry group of the crystal which satisfies the determining conditions. Investigation of the unreduced representations of the group T_h^6 showed that there are four such representations connected by the vector $\underline{k} = 1/2(\underline{b}_1 + \underline{b}_2 + \underline{b}_3)$ where

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Phase Transitions of the Second Order in Crystals with Symmetry T_h^6

$\underline{b}_1$, $\underline{b}_2$, $\underline{b}_3$ are reciprocal lattice vectors and three representations connected by the vector $\underline{k} = 0$. The first four representations permit the transition T_h^6 to C_i and are accompanied by doubling of the unit cell. The other three retain the volume unchanged. One is T_h^6 to T^4, another is T_h^6 to D_{2h}^{15} and the third is either T_h^6 to C_{2v}^5 or to C_3^4 according to the thermodynamic potential Φ.
The circumstance that one and the same representation can be connected with two different phase transitions shows that there is the possibility of the existence in the (p, T) diagram of a line of first-order transitions beginning at a point lying on the line of phase transitions of the second order. In the case examined, the line of first-order transitions separates phases with symmetry C_{2v}^5 and C_3^4. Along the line of

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Phase Transitions of the Second Order in Crystals with Symmetry T_h^6

second-order transitions intersecting it, on one side of the point of intersection, the transitions T_h^6 to C_{2v}^5 take place and on the other side the transitions T_h^6 to C_3^4. The lines of phase transitions of the second order connected with other representations cannot intersect in this way with lines of phase transition of the first order. There are 2 Soviet references.

ASSOCIATION: Khar'kovskiy fiziko-tekhnicheskiy institut (Khar'kov Physico-technical Institute)

SUBMITTED: March 19, 1958

LYUBARSKIY, G.Ya.; POVZNER, A.Ya.

Theory of wave propagation in irregular wave guides. Zhur. tekh.fiz. 29 no.2:170-179 F '59. (MIRA 12:4)

1. Fiziko-tekhnicheskiy institut AN USSR i Institut radiofiziki i elektroniki AN USSR, Khar'kov.
(Wave guides)

21(7)

AUTHORS: Lyubarskiy, G. Ya., Polovin, R. V. SOV/56-36-4-45/70

TITLE: On the Disintegration of Unstable Shock Waves in Magnetohydrodynamics (O rasshcheplenii neustoychivykh udarnykh voln v magnitnoy gidrodinamike)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 4, pp 1272-1278 (USSR)

ABSTRACT: In the present paper the authors investigate the fate of an unstable magnetohydrodynamic shock wave on the basis of the simple example of a plane steady shock wave in a perfect gas; the magnetic field is assumed, along both sides of the wave plane, to form only small angles to the vertical on this plane. The authors show that such a wave must necessarily disintegrate into several (theoretically seven) waves; among them there are fast and slow plane magnetoacoustic shock waves and similarity waves; Alfven discontinuities, and a contact discontinuity. This paper consists of 4 parts. The first discusses the problem and gives a qualitative analysis of the disintegration of such an unstable shock wave. In the 2. part the problem of the method of successive approximation in zero-th approximation for a negligible tangential magnetic field is

investigated. An unstable shock wave which is split up into two discontinuities serves as a basis. In this approximation the distance between the discontinuities formed does, however, not change with time. In order to be able to explain the possibility of such splitting-up it is, therefore, necessary to investigate also the following approximation. Part 3 deals with the problem of taking the tangential magnetic field in first approximation into account. In this approximation the primary shock wave is disintegrated into 4 discontinuities. In part 4, finally, it is shown that if the tangential magnetic field is taken into account, the distance between the discontinuities formed grows. The process of the disintegration of shock waves is thus connected with an increase of entropy. In a stable shock wave there is no such disintegration. The authors finally thank A. I. Akhiyezer, A. S. Kompaneyets, L. D. Landau, and I. M. Lifshits for discussions and advice. There are 1 figure and 12 Soviet references.

On the Disintegration of Unstable Shock Waves in Magnetohydrodynamics SOV/56-36-4-45/70

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Physico-technical Institute of the Academy of Sciences, Ukrainskaya SSR)

SUBMITTED: October 30, 1958

Card 3/3

21(7)

AUTHORS: Lyubarskiy, G. Ya., Polovin, R. V.

SOV/20-128-4-13/65

TITLE: On the Piston Problem in Magnetic Hydrodynamics

PERIODICAL: Doklady Akademii nauk SSSR, 1959, Vol 128, Nr 4, pp 684-687 (USSR)

ABSTRACT: The theorem of Chapman-Zhuge which remained a hypothesis for a long time, was first investigated by Ya. B. Zel'dovich (Ref 1) by detonation in a cylinder. The present investigation aims at a qualitative examination of the simplest piston problem in magneto-hydrodynamics while the piston is moving with a constant velocity. The motion of the substance ahead of the piston must be more complicated in magneto-hydrodynamics than in hydrodynamics as the state of the compressible conducting fluid is characterized by 7 instead of 3 quantities. The authors investigated the semi-space $x > 0$; it is filled with an ideal conductive fluid which is in a magnetic field and is at rest at the time $t = 0$. The fluid's state is characterized by the density ρ_0, the pressure p_0, and the components H_x, H_{oy}, $H_{oz} = 0$ of the magnetic field. The thermodynamical state equation of the fluid is optional and the

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validity of the inequalities $\left(\frac{\partial^2}{\partial p^2}\frac{1}{\varrho}\right)_s > 0$, $\left(\frac{\partial p}{\partial T}\right)_\varrho > 0$ is assumed. The fluid is bounded on the left by the piston which is in the plane x = 0. At the time t the piston begins moving with a constant velocity parallel to the Ox-axis. The motion of the fluid will be described by application of similarity and therefore all quantities depend solely on the ratio x/t. The developing discontinuity should be stable as related to a splitting up. According to A. I. Akhiyezer, G. Ya. Lyubarskiy, R. V. Polovin (Ref 4), V. M. Kontorovich (Ref 5), and S. I. Syrovatskiy (Ref 6) there are 3 types of steady shock waves, i.e. fast and slow magneto sound waves and Alfvén waves. Only the magneto sound wave can run ahead (shock wave or a wave by application of similarity), followed by the Alfvén wave and finally by the slow magneto sound wave (shock wave or wave by application of similarity). Some of these waves may be missing; there is a total of 17 variants. But actually there only are 2 variants, a slow and a fast magneto sonic wave in case the piston is moving against the fluid and a fast and a slow "self-modelling" wave when the piston moves in opposite direction. The Alfvén wave is missing in both cases. In this way the peculiar phenomenon of the "electrodynamic viscosity" is obtained. A tangential magnetic field in magnetic sound waves does not change the direction (L. D. Landau, Ye. M. Lifshits Ref 7; A. I. Akhiyezer, G. Ya. Lyubarskiy, R. V. Polovin Refs 8,9). The tangential magnetic field increases in fast shock waves and decreases in slow ones. When the tangential component equals zero on one side of the shock wave or of the magneto sonic wave obtained by application of similarity then it is parallel to the tangential component of the magnetic field on the other side. The density increases in shock-like magneto sound waves and remains constant in Alfvén waves. The tangential magnetic field turns in an Alfvén wave about an arbitrary angle without changing its magnitude. The corresponding mathematical relations are written down and briefly discussed. The authors express their gratitude for the suggestion of the theme to L. I. Sedov, to A. I. Akhiyezer and A. S. Kompaneyets for discussing the results of this investigation. There are 13 references, 12 of which are Soviet.

On the Piston Problem in Magnetic Hydrodynamics SOV/20-128-4-13/65

ASSOCIATION: Khar'kovskiy gosudarstvennyy universitet im. A. M. Gor'kogo (Khar'kov State University imeni A. M. Gor'kiy). Fiziko-tekhnicheskiy institut Akademii nauk USSR (Physical-technical Institute of the Academy of Sciences, UkrSSR)

PRESENTED: May 27, 1959, by L. I. Sedov, Academician

SUBMITTED: May 16, 1959

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LYUBARSKIY, Grigoriy Yakovlevich

The application of group theory in physics. New York, London, Pergamon Press, 1960.
ix, 380 p. diagrs., tables.
Translated from the original Russian: Teoriya Grupii i Yeye Primeniye v Fizike, Moscow, 1957.
Bibliography: p.375-380.

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[Theory of simple waves] K teorii prostykh voln. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. 40-43 p. (MIRA 17:1)
(Shock waves) (Magnetohydrodynamics)

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[The piston problem in magnetohydrodynamics] Zadacha o porshne v magnitnoi gidrodinamike. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. 40-43 p. (MIRA 17:2)

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[Kinetic theory of shock waves] K kineticheskoi teorii udarnykh voln. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. 58-63 p. (MIRA 17:1)

(Shock waves)

LYUBARSKIY G. YA.

S/185/60/005/003/002/020
D274/D303

26587

24.6731

AUTHORS: Lyubars'kyy, G.Ya., Nekrashevych, O.M. and Rozentsveyg, L.N.

TITLE: A semi-empirical method of calculating the accelerating system of a standing-wave linear proton-accelerator

PERIODICAL: Ukrayins'kyy fizychnyy zhurnal, v. 5, no. 3, 1960, 308-316

TEXT: This investigation was conducted in connection with the design of the linear proton-accelerator at the Physico-technical Institute of the AS UkrSSR. A semi-empirical method was chosen because neither a purely theoretical, nor a "trial-and-error" method would satisfactorily solve the problem. The macroscopic properties of the field in the n-th section of the accelerator are characterized by the mean intensity of the electric field:

$$\overline{E} = \frac{1}{L_n} \int E_z dz \qquad (1)$$

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the integration being carried out over the segment L_n of the resonator-axis which lies in the n-th section. In the following, L_n will be called the period of the accelerating system; L_n increases with n. It is assumed that $\overline{E}$ = const. This can be achieved in practice if the increase in L_n with n is compensated by a corresponding change in other geometrical parameters of the drift tubes; the position of the adjustment discs was chosen as such a parameter. The method involves the following assumptions: a) By dividing the resonator (by means of metal plates normal to the axis) into isolated sections, so that every section contains only one drift tube, and if the position of the adjustment discs is chosen so that the natural frequency f of each section is the same, then it is possible (in the ideal case) to obtain $\overline{E}$ = const. along the entire resonator, f being its natural frequency; b) the fulfilment of condition $\overline{E}$ = const. can be checked by measuring the magnetic field strength near the peripheral surface of the resonator; homogeneity of magnetic field at the periphery is an indication of the "macroscopic" homogeneity of electric field at the axis; c) due to the very small

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ratio between the radius of the drift tube and resonator radius, the electric field in the accelerating gaps does practically not differ from the electrostatic field which would arise between the drift tubes as a result of a potential difference $\bar{E}L$; the electrostatic field can be simulated by an electrolytic bath. The motion of the ion beam in the accelerator involves the coefficients:

$$A = \frac{1}{L}\int_{-\frac{L}{2}}^{\frac{L}{2}} E_z(z)\sin\frac{2\pi z}{L}\,dz, \qquad B = \frac{1}{L}\int_{-\frac{L}{2}}^{\frac{L}{2}} E_z(z)\cos\frac{2\pi z}{L}\,dz. \qquad (2)$$

T is the period of the accelerating field. It is assumed that the proton traverses the path L during T. Equations are set up for determining A and B; these equations involve an experimentally determined function (by an electrolytic bath) and two integrals which were graphically calculated by means of the Amsler planimeter. The

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length of the drift tubes was calculated by:

$$\frac{dL_n}{dn} = \frac{e}{m}\frac{\overline{E}\lambda^2}{c^2}\sqrt{A_1^2 + B_1^2}\cos\psi_s = 0.489\cdot10^{-4}\overline{E}\ \frac{B}{cm}\ G_n\cos\psi_s \quad (10)$$

where λ is the wave length, ψ - the ion phase on its passage through the middle of the gap, ψ_s - the synchronous ion-phase. The choice of ψ_s is not only limited from below: $\psi_s > 0$, (the condition for phase stability), but also from above: $\psi_s < \psi_{s\ crit.}$ (which is the condition for radial stability); an equation is given for determining $\psi_{s\ crit.}$ as well as a graph with the dependence of $\psi_{s\ crit.}$ on L. The value of ψ_s was taken as equal to $\frac{1}{3}\psi_{s\ crit.}$; the graph shows that $\psi_{s\ crit.}$ is smallest at the first tubes. A concrete example is given illustrating the method. First $\overline{E}$ is found and then L. The dependence of L_n on n was found to be nearly linear. There are 12 figures and 2 Soviet-bloc references.

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ASSOCIATION: Fizyko-tekhnichnyy instytut AN USSR (Physico-technical Institute AS UkrSSR)

SUBMITTED: August 12, 1959

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89385

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B125/B204

9,1300 (also 1006)

AUTHORS: Kreyn, M. G., Lyubarskiy, G. Ya. (Odessa, Khar'kov)

TITLE: The theory of pass bands of periodic waveguides

PERIODICAL: Prikladnaya matematika i mekhanika, v. 25, no. 1, 1961, 24-37

TEXT: In the present paper, periodic waveguides are investigated. The propagation of an acoustic wave with the frequency ω in a waveguide is described by $\Delta\varphi + \frac{\omega^2}{c^2}\varphi = 0$ (0.1). Here, φ is the velocity potential ($\vec{v}$ = grad φ), $c = c(x,y,z)$ is the velocity of sound. On the boundary of the waveguide $\frac{\partial\varphi}{\partial n} = 0$ (0.2) holds. Here periodic waveguides (period 1) are investigated; such a cell is assumed to be a waveguide filled with a homogeneous dielectric and bounded by two metal surfaces $y = y_1(x)$, $y = y_2(x)$ $(-\infty < x < \infty)$. Electromagnetic oscillations are investigated, for which Eq. (0.1) also holds; c is then the velocity of

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The theory of pass bands of ...

light in the dielectric. Frequencies $\omega_1(k) \leqslant \omega_2(k) \leqslant \dots \leqslant \omega_n(k) \leqslant \dots$ ..., Im k = 0 are to be determined at which (0.1) has a solution of the type $\varphi(x,y,z) = e^{ikx}\,\psi(x,y,z)$, $\psi(x+l,y,z) = \psi(x,y,z)$ and satisfies the boundary conditions (0.2) (problem A_1) (problem A_2) (0.3) respectively. The frequencies $\omega_n(k)$ are periodic functions of k with the period $2\pi/l$. The interval passing through from $\omega_n(k)$ at a variation of k between 0 and π/l is called n-th pass band. A single "cell" V of the waveguide is assumed to be bounded by the smooth surface S and the surface S'. In all points n (ξ,η,ζ) located on S, and the corresponding points $(\xi+l,\eta,\zeta)$ on S', $\varphi(\xi+l,\eta,\zeta) = e^{ikl}\varphi(\xi,\eta,\zeta)$, $\frac{\partial}{\partial n}\varphi(\xi+l,\eta,\zeta) = e^{ikl}\frac{\partial}{\partial n}\varphi(\xi,\eta,\zeta)$ (1.1) holds. The natural frequencies $\omega_n^2(k)$ of the self-adjoint boundary value problem have minimaximal

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properties: $\omega_n^2(k) = \max\limits_{(u_1,\dots,u_{n-1})} \inf\limits_{(u \perp u_1,\dots,u_{n-1})} \frac{I_1\{u\}}{I_2\{u\}}$ (1.3).

From (1.3) there follows: 1) The $\omega_n(k)$ depend monotonically and continuously on $\rho(x,y,z) = c^{-2}(x,y,z)$. The increase $\delta\omega_n^2(k)$ due to $\delta\rho$ satisfies $\left|\frac{\delta\omega_n^2(k)}{\omega_n^2(k)}\right| \leqslant \sup\limits_{x,y,z} \left|\frac{\delta\rho(x,y,z)}{\rho(x,y,z)}\right|$. 2) Every deformation neither changing V nor decreasing the period of the waveguide surface increases all eigenfrequencies $\omega_n(k)$ of the problems $A_2(S)$ and A_2. 3) ω_n is a prime number, and the corresponding eigenfunction is positive within V. The eigenfrequencies of the problems $A_i'(S)$ and $A_i''(S)$ $(i = 1,2)$ are expressed by $\Omega_{in}(S)$ and $\omega_{in}(S)$. Also these frequencies have minimaximal properties. $\omega_n(S) \leqslant \omega_n(k) \leqslant \Omega_n(S)$ (2.3) holds. This has

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been derived already in 1946 by V. V. Vladimirskiy (Ref. 5) and somewhat later by T. M. Karaseva and G. Ya. Lyubarskiy (Ref. 6). For the first pass band $\omega_1(\pi/l) = \Omega_1(\sigma)$ holds, its upper limit is a "π-wave" (i.e. the frequency $\omega_1(\pi/l)$ corresponding to the oblique periodic function $\varphi_1(x,y,z,\pi/l)$) and its lower limit is the frequency $\omega_1(0)$ corresponding to the periodic function $\varphi_1(x,y,z,0)$. The function $\frac{1}{2}\left[\varphi(x,y,z,k) + \varphi(-x,y,z,k)\right] = \psi(y,z) \cos kx$, at $k = \pi/l$ is a π-wave.

Theorem 2.2: The cylinder C with the volume V is assumed to have a cross section x = const of constant size and form. The cylinder is assumed to be bounded by the two parallel surfaces S and S'. The first natural frequency $\omega_1(S)$ of the problem $\Delta\varphi + \frac{\omega^2}{c^2(y,z)}\varphi = 0$ $\varphi = 0$ on S and S' assumes the lowest value, if S is the normal section of the cylinder. For the group velocity

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$$\frac{d\omega_n}{dk} = \frac{1}{2\omega_n(k_o)} S(\varphi_n,k); \quad S(\varphi_n,k) = \frac{i}{I_2\{\varphi_n\}} \iint_V \left[\varphi_n \frac{\partial \bar{\varphi}_n}{\partial x} - \bar{\varphi}_n \frac{\partial \varphi_n}{\partial x}\right] dydz \quad (3.3)$$

holds. Further, the estimate (3.4a) holds, which means that the group velocity is not greater than the greatest local signal velocity.

$$\left|\frac{d\omega_n}{dk}\right| \leqslant \frac{1}{\omega_n J_2(\varphi_n)} \int_V \left|\varphi_n \frac{\partial\varphi_n}{\partial x}\right| dv \leqslant \frac{1}{\omega_n J_2(\varphi_n)} \left(\int_V |\varphi_n|^2 dv \int_V |\operatorname{grad}\varphi_n|^2 dv\right)^{1/2} \leqslant$$
$$\leqslant \left(\frac{1}{J_2(\varphi_n)} \int_V |\varphi_n|^2 dv\right)^{1/2} \leqslant \max_{x,y,z} c(x,y,z) \qquad (3,4a)$$

Herefrom if follows for the width of each pass band that $\Delta\omega_n \leqslant \frac{\pi}{l} \max_{x,y,z} c(x,y,z)$ (3.6). For the collisions of the multiplier viz. the following theorems hold among others: Theorem 4.1: The multipliers $\rho_n(\omega)$ are symmetric to the unit circle if ω is real.

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Theorem 4.2: The $\rho_n(\omega)$ are symmetric to the real axis. Theorem 4.3: The multiplier $\rho_n(\omega)$ cannot leave the real axis towards the unit circuit as long as it does not meet another multiplier. Finally, the limits of the first pass band are estimated (formulas 5.5, 5.6, 5.9, 5.10, 5.11, 5.12), and in the appendix (§ 6) the analyticity of the functions $\omega_n(k)$ are investigated.

$$\lambda = \int_V \left\{ \left| \frac{\partial \varphi_1}{\partial y} \right|^2 + \left| \frac{\partial \varphi_1}{\partial z} \right|^2 \right\} dv \Big/ \int_V |\varphi_1|^2 dv$$

Из (5.4) следует, что

$$\omega_1^2 \left(\frac{\pi}{l}\right) \geqslant \inf_u \frac{1}{J_2(u)} \left(\int_V \left\{ \left| \frac{\partial u}{\partial x} \right|^2 + \lambda_1 |u|^2 \right\} dv \right) \geqslant$$

$$\geqslant \min_{(y,z)} \inf_u \left(\int_0^l \left\{ \left| \frac{\partial u}{\partial x} \right|^2 + \lambda_1 |u|^2 \right\} dx \Big/ \int_0^l |u|^2 \frac{dx}{c^2(x,y,z)} \right) \qquad (5.5)$$

где

$$\lambda_1 = \inf_v \left(\int_S \left\{ \left| \frac{\partial v}{\partial y} \right|^2 + \left| \frac{\partial v}{\partial z} \right|^2 \right\} dy\,dz \Big/ \int_S |v|^2 dy\,dz \right) \qquad (5.6)$$

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$$\omega_1^2(k) \leqslant \inf_v \frac{J_1(u(y,z)e^{ikx})}{J_2(u(y,z))} = \inf_u \frac{\int_S \{|\operatorname{grad} u(y,z)|^2 + k^2|u|^2\}\, dy\, dz}{\int_S |u(y,z)|^2 \left[\frac{1}{l}\int_0^l \frac{dx}{c^2(x,y,z)}\right] dy\, dz} \quad (5.9)$$

$$\omega_1(0) \leqslant \frac{2.405\ldots}{R}\left[\min_r \frac{1}{2\pi l}\int_0^l\int_0^{2\pi} \frac{d\varphi\, dx}{c^2(x,r,\varphi)}\right]^{-1/2} \quad (5.12)$$

M. I. Vishik and L. H. Lyusterik are mentioned. There are 3 figures and 11 references: 10 Soviet-bloc and 1 non-Soviet-bloc.

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10.1410 1327, 2807, 2406, 2607

26.7114

21341
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D299/D304

AUTHOR: Lyubarskiy, G.Ya. (Khar'kov)

TITLE: On shock-wave structure

PERIODICAL: Prikladnaya matematika i mekhanika, v. 25, no. 6, 1961, 1041 - 1049

TEXT: Discontinuous solutions for the hydrodynamic- and magnetohydrodynamic equations are considered, whereby the discontinuities are divided into "allowed"- and "unallowed" discontinuities. There are 2 methods for distinguishing between allowed- and unallowed discontinuities. Below, this problem is considered in connection with socalled dissipative systems of equations. It is shown that the condition for stability of the discontinuity (with respect to resolution into several divergent ones), is the necessary condition that a unique shock-wave should correspond to the discontinuity. It is ascertained in which cases the shock profile contains discontinuities. The quasilinear system of type

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$$\frac{\partial u_f}{\partial t} + \frac{\partial}{\partial x} A_j(u) = \sigma_j \Psi_j(u) \quad (j = 1, \ldots, n) \qquad (1.1)$$

is considered, where A and Ψ are differentiable functions. The conditions are stated under which system (1.1) is dissipative. This means that not a single root $\omega = \omega_s$ ($s = 1, 2, \ldots, n$) of the equation

$$D(\omega, k) \equiv \det / i\omega\delta_{js} - ikA_{js}(u^o) - \sigma_j \Psi_{js}(u^o) / = 0 \qquad (1.3)$$

lies in the lower half-plane; in addition, if all the coefficients σ are positive and finite, then no roots are found on the real axis either. Those solutions of system (1.1) are considered, which are shock waves with constant velocity U, propagating without change in their form. Such solutions depend only on $\xi = x - Ut$, and satisfy the system of ordinary differential equations

$$- U \frac{du_j}{d\xi} + \frac{d}{d\xi} A_j(u) = \sigma_j \Psi_j(u) \qquad (2.1)$$

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in addition, these solutions approach certain limits $u^+ \in M$ and $u^- \in M$, if $\xi \to \infty$, and $\lim du/d\xi = 0$ if $\xi \to +\infty$. Such solutions are called by the author transient solutions. The condition is ascertained for the existence of a transient solution. System (2.1) is linearized; thereupon the transient solution $u(\xi)$ is expressed, for large negative ξ, by a linear combination of type

$$u - u^- = \sum_{r=1}^{\rho^-} C_r^- a^{(r)} \exp \nu_r^- \xi, \quad (2.5)$$

and for large positive ξ, by

$$u - u^+ = \sum_{r=1}^{\rho^+} C_r^+ b^{(r)} \exp \nu_r^+ \xi. \quad (2.6)$$

Solutions (2.5) and (2.6) can be continued to the point $\xi = 0$. At this point, the (n+1) conditions

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$$u_1(-0) = u_1(+0),\ u_s(-0) = u_s(+0)\quad (s = 1, \ldots, n)$$

should be satisfied. To satisfy these conditions one disposes of ρ^+ parameters C_r^+ and ρ^- parameters C_r^-. The sought-for condition for the existence of a unique transient solution is

$$\rho^- + \rho^+ = n + 1. \qquad (2.7)$$

The problem amounts to establishing the connection between this condition and the condition for stability (with respect to resolution) of discontinuities: $n^- + n^+ = n - 1$, where $n^-(n^+)$ denotes the number of phase velocities $V_j^-(V_j^+)$ which are lower (higher) than the velocity U of the wave front. This purely algebraic problem is solved by using certain specific properties of dissipative systems. Together with system (1.1), a number of auxiliary systems are considered. Further, Witham's theorem is proved. The proof involves the equation

$$w(V) \equiv \Delta_{m_1+1}(V) + i\,\frac{\vartheta_{m_1+1}}{k}\,\Delta_{m_1}(V) = 0 \qquad (3.4)$$

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as system (1.1) is dissipative, all the roots V of Eq. (3.4) are in the upper half-plane or on the real axis. Further, the shift of the roots ν of

$$D_1(\nu,\ U) \equiv \det\begin{vmatrix} -U\delta_{j_s} + A_{j_s}(u^\circ) \\ (-U\delta_{j_s} + A_{j_s}(u^\circ))\,\nu - \sigma_j\psi_{j_s}(u^\circ) \end{vmatrix} = 0, \qquad u^\circ = u^- \tag{2.4}$$

in the complex plane is considered, when the parameter U varies along the real axis. From the definition of D_1 it follows that

$$D_1(0,\ U) \equiv \Delta_m(U)\prod_{j=m+1}^{n}(-\sigma_j) \tag{4.2}$$

therefore, $\nu = 0$ is a solution of the equation $D_1(\nu,\ U) = 0$ if and only if U coincides with one of the phase velocities

$$V_1^{\,o} \leqslant V_2^{\,o} \leqslant \ \cdots \ \leqslant V_m^{\,o} \tag{4.3}$$

of the system (C^o) of lowest rank m. The number of roots $\nu(U)$ which are found on either side of the imaginary axis. changes only if U passes through the phase velocities of the systems with lowest- and

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highest rank respectively. The conclusions of this section are summarized by formula

$$\ell(U, u^o) = \ell(-\infty) + n^o(U, u^o) - n^*(U, u^o) \tag{4.4}$$

where n^o and n^* are the number of phase velocities V_j^o and V_j^* respectively which are lower than U. By means of formula (4.4) it is possible to calculate the sum $\rho^- + \rho^+$; from (4.4) follows

$$\rho^- + \rho^+ = n + \delta n^o - \delta n^* \tag{4.5}$$

where

$$\delta n^o = n^c(U, u^+) - n^o(U, u^-), \quad \delta n^* = n^*(U, u^+) - n^*(U, u^-).$$

Continuous shock profiles and profiles with discontinuities: On the basis of the mutual disposition of the phase velocities V_j^o and V_j^* and of the velocity U, it is possible to ascertain the condition for the existence of a unique shock wave, corresponding to a given discontinuity; the relevant necessary condition is

$$\delta n^o = 1 \tag{5.2}$$

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There are 18 references: 12 Soviet-bloc and 6 non-Soviet-bloc. The 4 most recent references to the English-language publications read as follows: C.S.S. Ludford, The structure of magnetohydrodynamic shock in steady plane motion. J. Fluid Mechanics, 1959, 5; G.B. Whitham, Some comments on wave propagation and shock wave structure with application to magnetohydrodynamics. Comm. Pure Appl. Math., 1959, 12, no. 1; P.D. Lax, Hyperbolic systems of conservation laws II. Comm. Pure Appl. Math., 1957, 10, no. 3; I. Bazer, Resolution of initial shear flow discontinuity in one dimensional hydromagnetic flow. Astrophys. J., 1958, 129, no. 3.

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24.2120 (1049, 1502, 1482)
26.2311

AUTHORS: Akhiyezer, A. I., Lyubarskiy, G. Ya., Polovin, R. V.

TITLE: Stability conditions of the electron distribution function in the plasma

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 3, 1961, 963-969

TEXT: The authors deal with the problem of the stability of the electron distribution function toward plasma oscillations. The behavior of these functions at $t \to \infty$ (t-time) is determined by special points of their Laplace transforms φ_p and f_p with respect to time ($p = i\omega$, ω - complex oscillation frequency). In the free plasma φ_p and f_p are connected by $f_p(u) = (p+iku)^{-1}\{g(u)+ikem^{-1}\varphi_p f_o'(u)\}$ (1) where u is the projection of the electron velocity on the wave vector $\vec{k}$, $f_o(u)$ the initial function of the distribution of u, and g the initial value of f(u,t). The necessary and sufficient condition for the stability of the distribution function $F_o(v)$

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is given by the vanishing of the roots of

$$G(s) \equiv \int_{-\infty}^{\infty} \frac{f_0'(u)du}{u-s} = \frac{k^2}{\omega_0^2}, \quad s = \frac{ip}{k} \tag{3}$$

(ω_0 plasma frequency) in the upper semiplane s at an arbitrary value $k(k > 0)$. The criterion for the stability of the distribution function $f_0(u)$ has the form

$$\int_{-\infty}^{\infty} \frac{f_0''(u)\,du}{u-u_l} < 0, \quad f_0'(u_l) = 0, \quad f_0''(u_l) > 0. \tag{6}$$

from which it follows that a distribution function having only one maximum is stable. This stability condition was observed by P. L. Auer (Ref.7: Phys.Rev.Lett.,1,411,1958). If the distribution function has two maxima, the function will not be stable. A further condition is that any spherically symmetrical distribution function $F_0(|v|)$ which is nowhere vanishing is stable. Since $f_0(u) = \int F_0(v)\,dv_\perp = 2\pi \int_0^\infty F_0(\sqrt{u^2+v_\perp^2})\,v_\perp dv_\perp$, (A)

holds, where $v_\perp$ is the velocity component of the electron which is perpendicular to $\vec{k}$, $f_0'(u) = -2\pi u F_0(|u|)$ is obtained. Hence (3) takes on the form

$$2\pi \int_{-\infty}^{\infty} \frac{uF_0(|u|)}{s-u} du = \frac{k^2}{\omega_0^2}. \quad (7)$$

from which

$$2\pi \int_{-\infty}^{\infty} \frac{uF_0(|u|)}{s-u} du - 2\pi^2 isF_0(|s|) = \frac{k^2}{\omega_0^2}. \quad (8)$$

follows. The stability condition leads to the fulfillment of the inequality: $-\int_{-\infty}^{\infty} F_0(|u|)du < 0$. If $g(\xi)$ is the Fourier component of the function $f_0'(u) = \int_{-\infty}^{\infty} g(\xi)e^{i\xi u} \cdot d\xi$ it can be represented in form

$$g(\xi) = -\int_0^{\xi} \psi(\xi-\xi')\psi(\xi')d\xi', \quad (10)$$

$$\psi(\xi) = \int_{-\infty}^{\infty} e^{-i\xi\lambda} d\sigma(\lambda)$$

if the distribution function is stable. Here $\sigma(\lambda)$ is an arbitrary continuous non-decreasing limited function. A certain stable distribution function corresponds to each of these functions. Representation (10) was obtained by A. I. Achizer, G. Ya. Lyubarskiy (Ref.3: Tr.fiz.otd.fiz.-mat. f-ta KhGU,6,13). With a sufficient length of the plasma wave and a sufficiently strong magnetic field $\vec{H}$ the dispersion equation has the following form:

$$1-\frac{\omega_0^2\cos^2\theta}{\chi}\int_{-\infty}^{\infty}\frac{f_0'(u)du}{\chi u-\omega}+$$

$$+\frac{\omega_0^2\sin^2\theta}{2\omega_H}\int_{-\infty}^{\infty}\left(\frac{1}{\chi u-\omega+\omega_H}-\frac{1}{\chi u-\omega-\omega_H}\right)f_0(u)\,du=0, \quad (12)$$

where $\chi = |k\cos\theta|$ and θ are the angles between $\vec{k}$ and $\vec{H}$ and ω_H = eH/mc the electronic gyrofrequency. In the following,

$$G_H(s)\equiv\int_{-\infty}^{\infty}\left(\frac{\cos^2\theta}{u-s}+\frac{\sin^2\theta}{2s_H}\ln\frac{u-s+s_H}{u-s-s_H}\right)f_0'(u)\,du=\frac{\chi^2}{\omega_0^2}, \quad (13)$$

$$s_H=|\omega_H|/\chi.$$

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is obtained. The necessary and sufficient condition of stability of the distribution function $f_o(u)$ is given by the fact that the roots of (13) must not lie in the upper semiplane. If s is real, the real and the imaginary part of the function $G_H(s)$ is given by

$$\operatorname{Re} G_H(s) = \cos^2\theta \int_{-\infty}^{\infty} \frac{f_0'(u)\,du}{u-s} + \frac{\sin^2\theta}{2s_H} \int_{-\infty}^{\infty} f_0'(u) \ln\left|\frac{u-s+s_H}{u-s-s_H}\right| du, \qquad (a)$$

$$\operatorname{Im} G_H(s) = \pi\cos^2\theta f_0'(s) + \pi\frac{\sin^2\theta}{2s_H} \int_{s-s_H}^{s+s_H} f_0'(u)\,du.$$

In this case the distribution function is stable if for all values s for which $\operatorname{Im} G_H(s) = 0$ the real part $G_H(s)$ is negative. An even distribution function is stable if it has a single maximum (for n=0).

$$\int_{-\infty}^{\infty} \frac{f_0'(u)\,du}{u-s} + \frac{ieE_0}{mk}\cos\theta \int_{-\infty}^{\infty} \frac{du}{u-s}\frac{d}{du}\left[\frac{f_0'(u)}{u-s}\right] = \frac{k^2}{\omega_0^2}, \qquad (17)$$

is obtained for the dispersion equation for high-frequency plasma oscillations where $f_o(u)$ is the initial function of the electron distribu-

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tion and θ the angle between $\vec{k}$ and $\vec{E}_0$. The stability condition of the distribution function $f_0(u)$ is obtained in the form

$$\int_{-\infty}^{\infty} \frac{f_0'(u)\,du}{u-u_l} - \frac{\pi e E_0}{4mk}\cos\theta f_0''(u_l) < 0, \qquad (18)$$

where u_i are the roots of equation

$$f_0'(u_l) + \frac{eE_0}{2\pi mk}\cos\theta \int_{-\infty}^{\infty} \frac{f_0''(u)}{u-u_l}\,du = 0; \quad e < 0.$$

(b)

The authors thank K. N. Stepanov and A. B. Kitsenko for valuable advice and assistance, L. D. Landau and M. A. Leontovich for discussion. Ya. Faynberg and B. Ya. Levin are mentioned. There are 10 references: 6 Soviet-bloc and 4 non-Soviet-bloc. The four references to English-language publications read as follows: F. Berz. Proc. Phys. Soc., B69, 939, 1956; P. D. Noerdlinger. Phys. Rev., 118, 879, 1960; O. Penrose. Phys. Fluids, 3, 258, 1960; P. L. Auer. Phys. Rev. Lett., 1, 411, 1958.

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Stability conditions of...

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Institute of Physics and Technology, Academy of Sciences, Ukrainskaya SSR)

SUBMITTED: October 27, 1960

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LYUBARSKIY, G.Ya.

Kinetic theory of shock waves. Zhur. eksp. i teor. fiz. 40 no.4:1050-1057 Ap '61. (MIRA 14:7)

1. Fiziko-tekhnicheskiy institut AN Ukrainskoy SSR.
(Shock waves) (Gases, Kinetic theory of)

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C111/C444

AUTHOR: Lyubarskiy, G. Ya.

TITLE: Construction of transitional solutions to non-linear equations

PERIODICAL: Akademiya nauk SSSR. Doklady, v. 140, no. 6, 1961, 1255-1258

TEXT: The solution $y(x)$ of the equation $y^{(n)}(x) = F(x,y, y', \ldots, y^{(n-1)})$ is called transitional, if it converges for $x \to -\infty$ and $x \to +\infty$ to certain limits q_1 and q_2 and $\lim_{x \to \pm\infty} y^{(k)}(x) = 0$, $k = 1,2, \ldots, n$.

Let $q_1 < 0$, $q_2 > 0$, $y^{(0)} = 0$.

Considered is

$$P_0\left(\frac{d}{dx}\right) y + f(x,y) = 0 \qquad (A)$$

where $P_0(\nu) = a_n \nu^n + a_{n-1} \nu^{n-1} + \ldots + a_1 \nu$ $(a_1 < 0,\ a_n \neq 0)$. All roots of $P_0(\nu) = 0$ be real and simple. Let $a_-(> 0)$ and $a_+(< 0)$ be numbers such that $P_\pm(\nu) \equiv P_0(\nu) + a_\pm = 0$ also possess only real simple roots.

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It is put $f(x,y) \in G(q_1 > q_2)$, if the following conditions are satisfied:

1) there exist $p_1 \leqslant q_1$ and $p_2 \geqslant q_2$ such that $f(x,p_1) \leqslant 0 (-\infty < x \leqslant 0)$ and $f(x,p_2) \leqslant 0 (0 \leqslant x < \infty)$, where $p_1 a_- = p_2 a_+$

2) in $D_-(-\infty < x \leqslant 0,\ p_1 \leqslant y \leqslant 0)$ and $D_+(0 \leqslant x < \infty,\ 0 \leqslant y \leqslant p_2)$ $f(x,y)$ is continuous in y uniformly with respect to x and y.

3) $f(x,0) > 0,\ -\infty < x < \infty$.

4) $$\frac{f(x,y_2) - f(x,y_1)}{y_2 - y_1} \begin{cases} < a_-, & (x,y_1),\ (x,y_2) \in D_-; \\ < a_+, & (x,y_1),\ (x,y_2) \in D_+, \end{cases}$$

5) with respect to y there exist uniform limits

$$f(-\infty, y) = \lim_{x \to -\infty} f(x,y) \quad (p_1 \leqslant y \leqslant 0);$$

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$$f(\infty, y) = \lim_{x \to +\infty} f(x, y) \quad (0 \leqslant y \leqslant p_2).$$

6) The function $f(-\infty, y)\, f(\infty, y)$ possesses the only zero $y = q_1$ ($y = q_2$) on the interval $(p_1, 0)$ ($(0, p_2)$).

Let S be the set of all continuous functions $\omega(x)$ on $[-\infty, 0]$ and $[0, \infty]$ such that the points $(x, y = \omega(x))$ lie in $D = D_- + D_+$ for all x $(-\infty < x < \infty)$.

The function $\omega_1 \in S$ be called steeper than $\omega_2 \in S$ if $\omega_1 - \omega_2 \in S$. Let Ω_0 be the least steep function and ω_0 the steepest function among all $\omega(x) \in S$. Let

$$H\omega(x) = \int_{-\infty}^{\infty} K(x,s)\, \varphi(s, \omega(s))\, ds,$$

where $\varphi(x,y) = ya(y) - f(x,y)$, $a(\xi) = \begin{cases} a_-, & \xi < 0 \\ a_+, & \xi > 0 \end{cases}$

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and $K(x,s)$ the Green function of the linear operator $P_0(d/dx) + a(y(x))$, satisfying the conditions $K(\pm\infty, s) = K(0,s) = 0$ ($-\infty < s < \infty$).

Theorem 1: If $f(x,y) \in G(q_1, q_2)$ then (A) possesses in S at least one transitional solution. Among the transitional solutions of (A) (if there are more than one) there exists a steepest one $\omega(x) = \lim_{n\to\infty} H^n \omega_0(x)$ and a least steep one $\Omega(x) = \lim_{n\to\infty} H^n \Omega_0(x)$.

Theorem 2: If $f(x,y) \in G(q_1, q_2)$ in (A) is replaced by $f_1(x,y) \gg f(x,y)$ $((x,y) \in D$, $f_1 \in G(q_1^0, q_2^0)$, $q_1^0 \leqslant q_1$, $q_2^0 \geqslant q_2)$ then the steepest solution and the least steep one $\omega(x)$, $\Omega(x)$ become steeper.

Theorem 3: If f only depends on y, f = f(y), if it satisfies

$$f(y) > 0, \quad q_1 < y < q_2, \quad f(y) < \begin{cases} a_-(y-q_1), & q_1 \leqslant y \leqslant 0, \\ a_+(y-q_2), & 0 \leqslant y \leqslant q_2, \end{cases}$$

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and if it is continuous on $[q_1, q_2]$, then (A) possesses a monotone transitional solution.

Let $f(x,y) = f(y) + \Psi(x) \in G(q_1, q_2)$; $f(y)$ be monotone on $(p_1, 0)$, $(0, p_2)$ and satisfy outside of the interval $\alpha < y < \beta$ $(q_1 < \alpha < 0 < \beta < q_2)$ the condition

$$\left| \frac{f(y_2) - f(y_1)}{y_2 - y_1} \right| > d, \quad \alpha < y_1 < y_2 < \beta \qquad (6)$$

where $d > 0$. Then (A) possesses a unique solution in S. Let $\Psi(f)$ be the set of all functions Ψ, for which $f(y) + \psi(x) \in G(q_1^o, q_2^o)$ $(q_1^o \geqslant p_1, q_2^o \leqslant p_2)$. To every $\psi \in \Psi(f)$ let correspond the solution of (A): $y(x) = T\psi(x)$.

Theorem 4: The operator T is continuous, if one takes $y(x) \in S$ and $\psi(x) \in \Psi(f)$ to be elements of the space $C(-\infty, \infty)$.

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Theorem 5: The equation $P_0(d/dx)y + f(y) + V(y) = 0$ possesses a transitional solution in S, if

1) $f(y)$ is defined on $[p_1, 0]$ and $[0, p_2]$, being continuous and monotone satisfying (6)

2) $$\frac{f(y_2) - f(y_1)}{y_2 - y_1} \begin{cases} < a_-, & y_1, y_2 < 0, \\ > a_+, & y_1, y_2 > 0, \end{cases} \quad f(q_1) = f(q_2) = 0$$

3) $V(y) \geqslant 0 \quad (q_1 \leqslant y \leqslant q_2)$; $V(y) = 0 \; (y \bar{\in} (q_1, q_2))$

4) $V(y)$ being continuous in $p_1 < y \leqslant 0$ and $0 \leqslant y < p_2$

5) $$\max_{p_1 < y \leqslant 0} V(y) \leqslant -f(p_1), \quad \max_{0 \leqslant y < p_2} V(y) \leqslant -f(p_2)$$

Theorem 6: The equation $P_0(d/dx)y + f(y) + \varepsilon\Phi(y, y', \ldots, y^{(n-1)}) = 0$ possesses a transitional solution, if $f(y)$ satisfies the conditions of

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theorem 5, $\varepsilon > 0$ being sufficiently small and Φ possessing a bounded gradient in a certain domain of $y, y', \ldots, y^{(n-1)}$ which depends on $f(y)$.

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There are 5 Soviet-bloc and 6 non-Soviet-bloc references. The four references to English-language publications read as follows: H. Grad, Comm. on Pure and Appl. Math., 2, 331 (1949); G. B. Whitham, Comm. Pure and Appl. Math., 12, 113 (1959); W. Marshall, Proc. Roy. Soc., A 233, 367 (1955); C. S. S. Ludford, J. Fluid Mech., 5, 387 (1959).

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk USSR (Physicotechnical Insitute of the Academy of Sciences Ukrainskaya SSR)

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AUTHORS: Akhiyezer, A. I., Lyubarskiy, G. Ya., Pargamannik, L. E.

TITLE: Dynamics and stability of charged particle motion in a linear accelerator

SOURCE: Teoriya i raschet lineynykh uskoriteley; sbornik statey. Fiz.-tekhn. inst. AN USSR. Ed. by T. V. Kukoleva. Moscow, Gosatomizdat, 1962, 38 - 80

TEXT: The motions of a particle bunch in standing- or traveling-wave linear accelerators are considered. The theory is based on the following assumptions: A certain "fundamental particle" travels with the velocity $c\beta$ through all sections of the accelerator at strictly predetermined phases φ, designated as synchronous phase of the section. The initial conditions on injection can differ from the initial conditions of the fundamental particle in phase, radius, magnitude or direction of velocity. Studying the stabilities of the longitudinal and transverse motions of the accelerated particle leads to differential equations of the form $\ddot{q} + \Omega^2(t)q = 0$ (2.1), with $\Omega^2(t)$ positive or negative. From (2.1) the approximate equations

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$$\left.\begin{aligned} q_{k+1} &= a_{11}(k)\,q_k + a_{12}(k)\,\dot{q}_k, \\ \dot{q}_{k+1} &= a_{21}(k)\,q_k + a_{22}(k)\,\dot{q}_k. \end{aligned}\right\} \qquad (2.6)$$

are derived. Formulating

$$\left.\begin{aligned} q_k &= A_k \exp\left\{i\sum_{m=0}^{k-1}\gamma_m,\right. \\ \dot{q}_k &= B_k \exp\left\{i\sum_{m=0}^{k-1}\gamma_m.\right. \end{aligned}\right\} \qquad (2.7)$$

yields the general solution of (2.1):

$$q_k = A_0\left(\frac{\Omega_0}{\Omega_k}\right)^{1/2}\cos\left(\sum_{i=0}^{k-1}\tau_i\Omega_i + \theta\right), \qquad (2.11);$$

$A_o = \sqrt{q_o^2 + (\dot{q}_o^2/\Omega_o^2)}$. The differential equation $\frac{d}{dt}(\dot{q}/\sqrt{1-\beta^2}) + \Omega^2(t)q = 0$ has the solution

$$\varphi_k = A_k \cos(\varphi_k + 0) = A_0 \left(\frac{1-\beta_k^2}{1-\beta_0^2}\right)^{1/4} \times$$
$$\times \left(\frac{\hat{\Omega}_0}{\hat{\Omega}_k}\right)^{1/2} \cos\left(\sum_{l=1}^{k-1} \hat{\Omega}_l \tau_l + 0\right). \qquad (2.16),$$

where $\hat{\Omega}$ is the frequency of the oscillations. The longitudinal wave is stable in the synchronous phase range $0 < \varphi_s < \pi/2$. In this range the scattered particle does not escape from the acceleration process. The stability of the longitudinal oscillations decreases as the synchronous phase increases. The capture width $\Delta\varphi = \phi_m + \varphi_s = 2\pi\kappa$; if $\varphi_s \ll 1$, $\Delta\varphi = 3\varphi_s$; φ_m is the maximum, φ_s the synchronous phase. In the case of transverse oscillations the non-relativistic frequency of the particles is $\Omega_r^2 = G - (1/2)(1-\beta^2)C\sin\varphi_s$, and their relativistic frequency is $\hat{\Omega}_r^2 = \sqrt{1-\beta^2}\left\{G - (1/2)(1-\beta^2)C\sin\varphi_s\right\}$. G is the radial force exerted by the

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radial focusing fields. When $G > 0$, a positive synchronous phase exists, and the longitudinal and transverse phases are stable simultaneously. The defocusing effect of the space charge can be neglected when the effective currents amount to a few hundred ma. Simultaneous longitudinal and transverse stability is simply achieved by focusing with foils. The focusing effect of a magnetron lens is described by $G = (\gamma/N)(eH/2mc)^2 m/m_0$; for protons, it is 1840 times greater than the focusing effect of a longitudinal magnetic field. There are 14 figures.

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B125/B102

24.6730

AUTHORS: Lyubarskiy, G. Ya., Nekrashevich, A. M., Rozentsveyg, L. N. (Deceased)

TITLE: A semi-empirical method of calculating the acceleration system in a standing-wave linear accelerator

SOURCE: Teoriya i raschet lineynykh uskoriteley; sbornik statey. Fiz.-tekhn. inst. AN USSR. Ed. by I. V. Kukoleva. Moscow, Gosatomizdat, 1962, 81 - 93

TEXT: The present semi-empirical calculation of a proton linear accelerator (volume resonator exciting standing E_{01} waves) avoids the extremely difficult calculation of the field distribution in resonators that have axially distributed shielding tubes. These tubes shield the protons from the influence of the decelerating electric field. This accelerator was designed and constructed between 1947 and 1950 in the Fiziko-tekhnicheskiy institut AN USSR (Physicotechnical Institute AS UkrSSR). Its main problem is to combine radial with longitudinal stability. Radial stability is attained by nets at the front end of the shielding tubes. The resonator is subdivided into

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sections with one shielding tube each. According to A. M. Nekrashevich, the frequencies of these sections can be varied in a manifold manner by attaching metal discs on the shielding tubes. The eigenfrequency of the section with the shortest tube and discs at the end is equal to the eigenfrequency of the longest tube with discs at its center. The coefficients A and B in the equations of motion of the ion beam are transformed to

$$\left.\begin{aligned} A &= \frac{1}{L}\int_{-L/2}^{L/2} E_z(z)\sin\frac{2\pi z}{L}\,dz; \\ B &= \frac{1}{L}\int_{-L/2}^{L/2} E_z(z)\cos\frac{2\pi z}{L}\,dz. \end{aligned}\right\} \qquad (2a)$$

where L is the period of the accelerating system. The field in the accelerating gaps is practically equal to the electrostatic field between the shielding tubes. It is, therefore, simulated with the aid of the volume variant of the electrostatic bathtube. Measurements for L = 12, 16,...56 cm give